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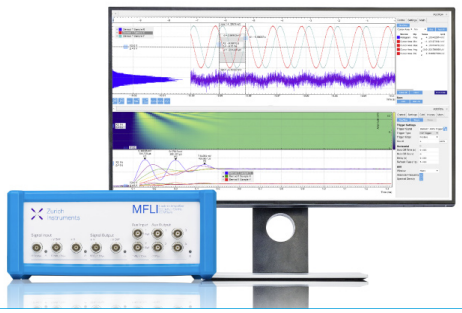

Effect of graphene reinforcement on mechanical and microstructure behavior of AA8030/Graphene composites fabricated by stir casting technique

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Abstract: Aluminum matrix composite currently used in engineering applications due to their desirable combination of properties. Development of aluminium matrix composite has become an essential area of research interest in material science. Aluminium based graphene composite are finding increased application in electrical, automobile and aerospace applications because of its light weight. In this present work dealt with mechanical and microstructure properties AA8030 reinforced with 5 different wt% of Graphene. The bottom pouring stir casting machine was used to fabricate AA8030-Graphene composite. Fabricated samples were tested according to the ASTM standard. The microstructure and mechanical properties such as hardness, tensile strength, flexural strength of fabricated samples were evaluated.

Keywords: AA 8030; graphene; stir casting machine; Hardness; Tensile strength; flexural strength; SEM.

1. Introduction

Composite materials defined more than two different elements. Metal matrix composite (MMC) combination of two constituent phases, one being a metal necessarily and other content may be a different metal such as a ceramic or organic compound. Metal matrix composites in general consist of continuous or discontinuous fibers, whiskers, or particulates dispersed in a metallic alloy matrix [1]. It leads to an increase in the strength in shear and compression and higher service-temperature capabilities. Thus, they have significant scientific, technological and commercial importance[2] . MMCs are being used extensively for high performance applications such as in aircraft engines and more recently in the automotive industry[3]. Hemanth et al. (2017) define composites as physical systems consisting of a mixture of two or more micro-constituents insoluble in each other and differing in form and materials composition. Santhosh et al. (2018) prepared Kevlar/Basalt/E-glass reinforced epoxy matrix composites by vacuum bag moulding process and analysed its flexural and impact behaviours. They reported that higher volume fraction of fiber enhances the flexibility of composite laminate and higher matrix percentage cut downs the impact energy absorption capacity of hybrid composites[4]. Natrayan (2018) reported MMCs to combine metallic properties (high strength and high modulus), leading to greater strength in shear and compression and higher service temperature capabilities. Interest in MMCs for aerospace, automotive and other structural applications has increased over last fifteen years as a result of availability of relatively inexpensive reinforcements, and the development of various processing routes which result in reproducible microstructures & properties[5]. In AMC the matrix phase is of pure aluminium or an alloy of it and the reinforcement used is a non-metallic ceramic such as SiC, Al_2O_3, SiO_2, B_4C and graphene. Aluminium composites have good corrosion resistance, high damping capacity, low density and excellent electrical and thermal conductivities[6]. Graphene is a two-dimensional carbon material showing a unique combination of mechanical and thermal properties[7]. M.Senthil Kumar et al (2019) investigates the AMMC fabricated through squeeze casting technique, reinforcement particle size 10 µm shows better mechanical and tribological properties[8]. Yogeshwaran S et al. (2015) concluded hardness and tensile strength of AMMC were increased by adding reinforcement up 10wt% using the method of stir casting[9]. Sai Jagadish B et al.

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(2013) investigate hardness, flexure and tensile strength of Aluminium powder/ graphene composites fabricated by stir casting route and results show that mechanical properties decreased with increasing the graphene reinforcement percentage[10]. Venkatesan S et al. (2019) reported that Al/graphene composition gradual increase the mechanical properties. The stir casting has more effective composition than the normal cast[11]. From the literature survey, many authors reported on Aluminium matrix composite. Few authors reported on fabrication method Aluminium/graphene composite. This paper investigates the mechanical properties of Aluminium/graphene composite fabricated by stir casting method.

2. Methods and methodology

2.1. Selection of Materials

In this study AA8030 used as base metal, it has unique metal that reacts with oxygen in the air to form a skinny layer of oxide; however, this layer is dense and provides the metal excellent corrosion protection. Table 1 shows the chemical composition of AA8030 alloy.

Table-1 AA8030 chemical composition

Elements	Al	Fe	Cu	Si	Mg	Zn	B	Other
Contents %	98.5	0.3	0.35	0.5	0.26	0.05	0.01	0.03

Fig 1: AA8083 Wire

Graphene is used as reinforcement; Graphene is a single layer of sp2-bonded carbon atoms that are packed in a honeycomb lattice, Its sp2-hybridized two-dimensional single-atom thick-layer structure and unique thermal, electrical and mechanical properties, graphene has been extensively investigated in recent years. Graphene has a very high specific surface area (2630 m^2 g^{-1}), electron mobility exceeding 15000 cm^2 V^{-1} S^{-1} at room temperature and thermal conductivity of about 5000 W/mK. Graphene particle size 32µm supplied by a scientific research laboratory. The particle size of graphene was verified using a Malvern laser size analyzer[12]. Specimen preparations were showed in table 2.

Table 2: sample preparation

Sample no	AA8083 (g)	Graphene (g)
S1	1000	-
S2	995	5
S3	990	10
S4	985	15
S5	980	20

2.2. Experimental procedure

AA8083/Graphene composite fabricated through bottom pour stir casting machine. Experimental setup showed in fig 2. Mechanical stirrer used for distributing mixing of reinforcement in to the molten metal. Electric induction furnace has been used for getting liquid metal, reaching 500°C raw materials were put into the furnace to getting liquid metal. Reaching of the liquid state of aluminium alloy was melted. At the same time, the graphene

powder was preheated in a muffle furnace set at 100°C for approximately 2 hours to remove surface impurities and assist in the absorption of gases.

Fig 2: Bottom Pour Stir Casting Machine

The preheated graphene powder was poured slowly and continuously into the molten metal and the melt was continuously stirred at 600 rpm[13]. In preparing metal matrix composites by the stir casting method, several factors need considerable attention, including the difficulty of achieving a uniform distribution of the reinforcement material, wettability between the two main substances, porosity in the cast metal matrix composites, and chemical reactions between the reinforcement material and the matrix alloy after that complete mixture poured into the preheated die to obtaining casting.

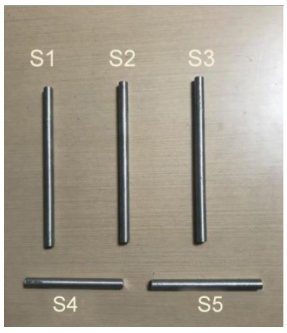

Fig 3: Machined composite sample

2.3. Characterization

The cast specimen was machined for testing purpose using CNC and lathe to get the required ASTM standard dimension for taking mechanical and microstructure test. For microstructure test, the samples were prepared by first rubbing them with emery paper of grade upto 1200 grit size which was followed by polishing the surface of the specimen using Keller's reagent on a grinding machine using velvet cloth. These samples were then examined with a scanning electron microscope (SEM). Hardness test of the samples was carried out using Vickers hardness testing machine to find out hardness and effect of graphene composition in the samples at a load of 0.5 kgf and dwell time of 10 seconds. UTM machine was used to carry out the tensile properties at room temperature based on ASTM E8 standard[13].

3. RESULTS AND DISCUSSION

3.1 Hardness

Vickers hardness test results are shown in figure 4. Sample 3 (AA8030/10wt% graphene) shows high hardness value compare then pure AA8030 (sample 1). This shows that more than 10wt% graphene shows less hardness.

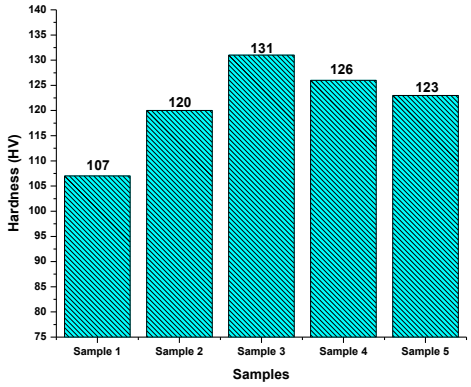

Fig. 4. Hardness values of composites

3.2 Tensile strength

Tensile strength samples results are shown in fig 5. The stresses of the five samples are 120MPa, 155Mpa, 182 Mpa, 166MPa and 159MPa respectively. Compare then base alloy, sample 3 tensile strength has increased 34%.

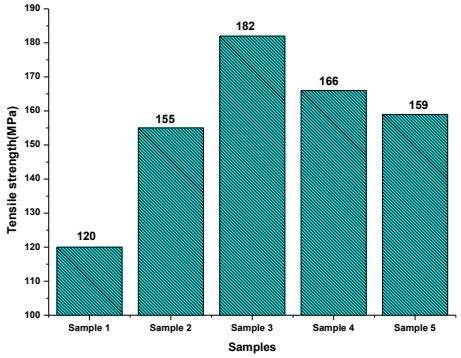

Fig. 5. Tensile strength of composites

3.3 Flexural strength

The material is laid horizontally over two points of contact (lower support span).Then a force is applied to the top of the material through either one points of contact (3-point flexure test) until the sample fails. Fig 6 exposed Flexural strength of composites; Sample 3 shows high flexural strength (40 MPa).

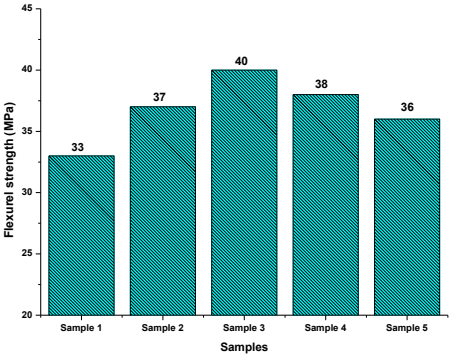

Fig. 6. Flexural strength of composites

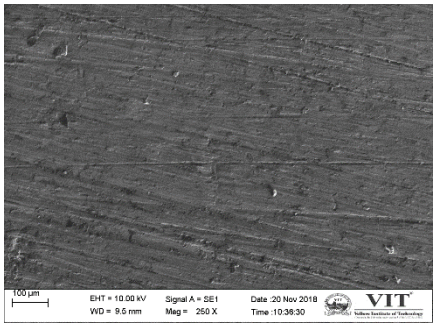

Fig.7. sample 1 (AA8030)

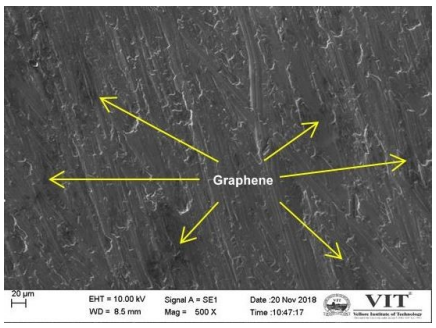

Fig.8. Sample 3 (AA8030/10wt% Graphene)

3.4 Microstructure

Sample 7 (AA8030) SEM shows in fig 7. It exposes cavity and dimples in fabricated composite. Fig 8 (AA8030/10wt% Graphene) shows graphene particles are uniformly distributed and seem to be scattered. The higher percentage of composite particles has led to higher distribution in the metal matrix. Fig 8 exposed the graphene particles occupied in grain boundary and reduced cavity voids.

4. CONCLUSIONS.

AA8030 reinforced different wt% of graphene was successfully fabricated by bottom pour stir casting method. The samples were characterized and drawn the following conclusions are:

- Stir casting technique was suitable to fabricate the AA8083 HMMC.
- Sample 3 (AA8030/10wt% graphene) shows maximum hardness, tensile strength and flexural strength. It has increased by 34% compare then base metal.
- SEM exposed that sample 3 shown less agglomeration with uniform distribution and fewer voids compared to sample 1.
- It was found that mechanical properties have increased with increasing the composition of graphene more than 10wt %.

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